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IS 8271-1 (1981): Quartz Crystal Units Used for Frequency Control and Selection, Part I: General Requirements and Tests [LITD 5: Semiconductor and Other Electronic Components and Devices]

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(Reaffirmed 2001)

Indian Standard

SPECIFICATION FOR QUARTZ CRYSTAL UNITS USED FOR FREQUENCY CONTROL AND SELECTION

PART I GENERAL REQUIREMENTS AND TESTS

(First Revision)

UDC 621·373·5

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INDIAN STANDARDS INSTITUTION
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September 1981

Indian Standard

SPECIFICATION FOR QUARTZ CRYSTAL UNITS USED FOR FREQUENCY CONTROL AND SELECTION

PART I GENERAL REQUIREMENTS AND TESTS

(*First Revision*)

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(*Continued on page* 2)

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Indian Standard

SPECIFICATION FOR QUARTZ CRYSTAL UNITS USED FOR FREQUENCY CONTROL AND SELECTION

PART I GENERAL REQUIREMENTS AND TESTS

(First Revision)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 2 February 1981, after the draft finalized by the Piezoelectric Devices for Frequency Control and Selection Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 This standard was originally published in 1976. The sectional committee responsible for the preparation of this standard felt that this standard does not fully cover the general requirements and tests for professional grade crystals for frequency control and selection. It was, therefore, decided to revise this standard incorporating the general requirements and tests for such crystals.

0.3 The object of this standard is to establish uniform requirements for the mechanical, electrical and climatic properties of quartz crystal units, to describe test methods and to give recommendations for the standard values.

0.4 The applicability of the tests to each type of crystal units and the specific requirements for each test will be stated in the relevant specification for the crystal units; should, however, any deviation exist between the provisions of this standard and those of the relevant individual specification, the provision of the latter shall prevail.

0.5 Since this standard covers only the general requirements and tests for quartz crystal units for frequency control and selection, information to be furnished by the purchaser, specifying the details of the units required, shall be as given in IS : 2935-1980*.

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*Guide to the use of quartz crystal units for frequency control and selection (*first revision*).

0.6 While preparing this standard assistance has been derived from:

a) IEC Publication 122-1 (Second edition)-1976 Quartz crystal units for frequency control and selection, Part I : Standard values and tests conditions. International Electrotechnical Commission.

b) JSS 50900 'General requirements for crystal units, quartz, Ministry of Defence, Government of India.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies general requirements and tests common to all types of quartz crystal unit, for frequency control and selection.

2. TERMINOLCGY

2.0 For the purpose of this standard, definitions covered in IS : 1885 (Part XLIV)-1978† and the following shall apply.

2.1 Type Tests — Tests carried out to prove conformity with requirements of the relevant specification. These are intended to check the general qualities and design of a given type of quartz crystal units.

2.2 Acceptance Tests — Tests carried out on samples selected from a lot for purposes of acceptance of the lot.

2.2.1 Unless otherwise specified, an inspection lot or batch shall be specified as in IS : 2612-1965‡ as far as practicable shall consist of crystal units of one type and one frequency or assorted frequencies within the range covered by that type produced under essentially the same conditions, and offered for inspection at one time. When assorted frequencies are submitted, they shall be unless otherwise specified at the lowest, highest and mid-point frequencies of the range.

---

*Rules for rounding off numerical values (*revised*).

†Electrotechnical vocabulary : Part XLIV Piezoelectric devices.

‡Recommendation for type approval and sampling procedures for electronic components.

2.3 Routine Tests — Tests carried out on every quartz crystal unit to check the requirements which are likely to vary during production.

2.4 Operating Temperature Range — The operating temperature range of a crystal unit is the ambient temperature range over which the unit will oscillate in accordance with the specified frequency and equivalent resistance requirements.

2.5 Operable Temperature Range — The operable temperature range of a crystal unit is the ambient temperature range over which units designed for controlled temperature conditions will oscillate though not necessarily within the specified tolerances.

2.6 Frequency Stability (Controlled) — Throughout the operating temperature range the frequency of crystal units designed for operation under controlled temperature conditions shall not deviate from the measured frequency at the reference temperature by more than the value specified and shall also be within frequency tolerance limits.

3. STANDARD OPERATING TEMPERATURE RANGES

3.1 The operating temperature ranges shall be as follows:

a) *Non-controlled Types*

- i) – 55°C to + 105°C
- ii) – 55°C to + 90°C
- iii) – 20°C to + 70°C
- iv) – 40°C to + 70°C
- v) 0°C to + 60°C
- vi) + 15°C to + 45°C

b) *Controlled Types*

- i) 65 ± 5°C
- ii) 75 ± 5°C
- iii) 85 ± 5°C
- iv) 65 ± 2°C
- v) 75 ± 2°C
- vi) 85 ± 2°C
- vii) 65 ± 1°C
- viii) 75 ± 1°C
- ix) 85 ± 1°C

4. STANDARD VALUES OF LOAD CAPACITANCE

4.1 The standard values of load capacitance for crystal units operating at the fundamental frequency of the mode are:

20 pF,
30 pF,
32 pF,
50 pF, and
100 pF.

4.2 Overtone crystals are often operated at series resonance. Where a load capacitance is used, it should be chosen from the list of standard values below:

8 pF, 10 pF, 12 pF, 15 pF, 20 pF, 30 pF.

NOTE — The tolerance on the load capacitance should be that value which results in a frequency change not exceeding 10 percent of the frequency tolerance at the reference temperature or 1 percent of the nominal load capacitance, whichever is smaller.

5. STANDARD LEVELS OF DRIVE

5.1 The standard levels of drive are:

10, 5, 2, 1, 0·5, 0·2, 0·1, 0·05, 0·02, 0·01, 0·001 and 0·0001 mW

The tolerance shall be ± 20 percent unless otherwise specified in the relevant specification.

6. TOLERANCE ON FREQUENCY

6.1 Standard values of tolerance shall be as follows:

±200, ±100, ±75, ±50, ±25, ±20, ±15, ±10, ±5, ±1, ±0·5, and ±0·1 parts per million.

NOTE — *See* Appendix A for example of tolerance quotation.

7. WORKMANSHIP AND CONSTRUCTION

7.1 Workmanship, Processes and Finishes — Crystal units shall be manufactured and processed in careful and workmans like manner in accordance with good design and sound engineering practice. Metal parts shall be free from burrs, sharp edges and corrosion effects.

7.2 Design and Construction — The crystal units shall be of the design and construction specified in the relevant detail specification. The external dimensions shall be as specified after assembling and marking.

7.2.1 *Crystal Holder* — The holder shall be of the type specified in the relevant detail specification and of the physical dimensions as shown therein.

NOTE — For crystal units employing pin terminations, use of undercut pin terminations shall be considered as optional.

7.2.2 *Supporting Structures* — For crystal units with metal plated quartz resonators, the supporting wires or other supporting structures shall be attached to the pins of the holder by soldering or welding.

7.2.3 *Bond* — For crystal units with metal plated quartz resonators, the supporting wires or other supporting structures shall be bonded to the quartz resonator by an electrically conductive cement. Other materials or processes may be used if prior approval is obtained from the qualifying authority.

8. MARKING

8.1 The following information shall be marked indelibly and legibly on the crystal holders:

a) Nominal frequency in kHz or MHz,
b) Manufacturer's name or trade-mark, or manufacturer's code number,
c) Type number or type designation [the crystal units shall be designated in accordance with the type of crystal unit holder in which the unit is to be fit in. For example, crystal units type AA-01 to AA-09 shall use the crystal unit holder type AA (*see* IS : 4750-1968 Specification for crystal holders)],
d) Month and year of manufacture,
e) Country of manufacture, and
f) Any other information necessary to obtain a complete definition of the unit.

NOTE 1 — It is recommended that fundamental crystal units should be marked in kHz and overtone units marked in MHz.

NOTE 2 — The addition of further information is optional but it should be marked in such a way as not to cause confusion with the marking required above.

NOTE 3 — If sufficient space is not available to mark these details on the crystal holder then (a), (b) and (c) shall be marked on the holder and others may be marked on carton.

8.2 The frequency shall be specified to the final hertz and shall consist of 7 digits or less for frequencies below 10 MHz, 8 digits or less for the range 10 MHz up to 100 MHz, and 9 digits for frequencies 100 MHz and above. Kilohertz shall be used with frequencies below 1 MHz and with frequencies from 1 MHz and above. The frequency marking shall occupy a maximum of 13 spaces, as follows: a maximum of 9 digits, a space for a decimal point, and 3 spaces for KHz or MHz whichever is applicable; typical crystal markings are 833·333 KHz, 55·777 778 MHz, and 234·666 668 MHz.

8.2.1 The characteristics of the marking shall be not less than 1·6 mm in height unless otherwise specified, arranged as illustrated in detail specifications and located symmetrically with respect to the centre axis of the crystal holder.

8.3 The holder containing the crystal units may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

9. TESTS

9.1 Classification of Tests

9.1.1 *Type Test* — The procedure for type tests shall be in accordance with IS : 2612-1965*.

9.1.1.1 *Number of samples* — The manufacturer shall submit 30 crystal units in each type of crystal unit for which approval is desired. If approval is desired for a limited frequency band within the crystal unit range, 30 crystal units shall be required in that band. Ten of the 30 crystal units shall be at the lower end, 10 near the middle and 10 at the upper end of the frequency range over which approval is desired.

9.1.1.2 *Sequence of type tests* — The sequence of type test shall be in accordance with Table 1.

9.1.1.3 *Grouping of crystal units for type approval* — Type approval obtained for one type of crystal units shall constitute approval of all others in the same group that follow it in group listing in Table (Under consideration). If a manufacturer qualifies for a limited frequency band within the frequency range of a crystal unit, corresponding limitation shall apply to the automatic approval of other types. In no case shall be frequency range of the type receiving automatic type approval extend beyond the frequency range for which type approval has been obtained. If the extension of the frequency range for crystal type does not exceed 20 percent of the total range, only the following tests are required for type approval.

a) Reduced drive level (**9.4**),
b) Resonance frequency and resonance resistance (**9.6**),
c) Temperature run (**9.8**),
d) Unwanted response (**9.9**), and
e) Sealing (**9.18**).

---

*Recommendation for type approval and sampling procedures for electric components.

TABLE 1 SEQUENCE OF TYPE TESTS

(*Clause* 9.1.1.2)

Sl No.	Test	Clause Number
1	General examination (external)	9.3.1
2	Glass parts	9.3.1.1
3	Pin alignment	9.3.1.3
4	Soldering (when applicable)	9.20
5	Shock	9.15
6	Vibration	9.16
7	Bump (when specified)	9.14
8	Reduced drive level	9.4
9	Capacitance shunt	9.5
10	Insulation resistance	9.12
11	Resonance frequency and resonance resistance	9.6
12	Operable temperature range	9.8.3
13	Low temperature storage	9.7
14	Temperature run	9.8
	a) Operating range (controlled)	9.8.1
	b) Operating range (non-controlled)	9.8.2
15	Unwanted response	9.9
16	Change of temperature	9.24
17	Thermal shock	9.19
18	Sealing	9.18
19	Salt mist	9.22
20	Composite temperature humidity cyclic (moisture resistance)	9.21
21	Ageing	9.23
22	Robustness of terminations*	9.17
	a) Tensile Test	9.17.2
	b) Bending test (under out pin terminations)	9.17.3
	c) Bending test (wire terminations)	9.17.4
23	General exemination (internal)†	9.3.2
	a) Resonator	9.3.2.1
	b) Holder cover	9.3.2.2
	c) Bond strength	9.3.2.3

*Two sample units only from those to be used for visual and mechanical examination (internal).

†Six sample units, two each from the lower end, middle and upper end frequency.

9.1.2 *Routine Tests* — The following tests shall constitute routine tests and shall be carried out on every crystal unit:

a) General examination (external) (**9.3.1**),

b) Measurement of resonance frequency and resonance resistance (**9.6**), and

c) Insulation resistance (**9.12**).

9.1.3 *Acceptance Tests*

9.1.3.1 Acceptance tests shall be carried out on a limited number of samples selected in accordance with IS : 2612-1965* from the lot which has been subjected to and satisfactorily completed the routine tests specified in **9.1.2**.

The inspection levels and acceptance quality levels, chosen from IS : 2612-1965* should be subjected to agreement between the purchaser and the manufacturer.

Two groups of samples one for non-destructive tests (Group A) and another for destructive tests (Group B) shall be selected (*see* Appendix B of IS : 2612-1965*) and the crystal units in each group shall be subjected to the tests as given in Table 2.

9.2 General Conditions for Tests

9.2.1 *Atmospheric Conditions for Testing* — Unless otherwise specified, all tests shall be carried out under standard atmospheric conditions specified in IS : 589-1961† as well as IS : 9000 (Part I)-1977‡.

9.2.2 *Other Precautions*

9.2.2.1 Before measurements are made the crystal units shall be stored at measuring temperature for sufficient time to allow the entire unit to reach this temperature.

9.2.2.2 During and between tests, the crystal unit should not be subjected to conditions likely to invalidate the results of the measurements.

9.2.2.3 *Measurements before and after a test* — When resonance frequency or resonance resistance or both are measured before and after a test for determining change during the test, both measurements shall be

---

*Recommendation for type approval and sampling procedures for electronic components.

†Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

‡Basic environmental testing procedures for electronic and electrical items: Part I General.

TABLE 2 ACCEPTANCE TESTS

(*Clause* 9.1.3.1)

Sl No.	Test	Clause Number	AQL (Percent Defective)	*Inspection Level	†D/N
Group O					
a)	General examination (external)	9.3.1	—	—	N
b)	Resonance frequency and resonance resistance	9.6			
c)	Insulation resistance	9.12			
	Note — The following tests shall be carried out on every crystal unit of the lot.				
Group A			1	II	N
a)	General examination (external)	9.3.1			
	i) Glass parts	9.3.1.1			
	ii) Pin alignment	9.3.1.3			
b)	Sealing	9.18			
c)	Temperature run	9.8			
d)	Unwanted response	9.9			
e)	Capacitance shunt	9.5			
f)	Reduced drive level	9.4			
Group B			4	5-3	D
a)	Soldering	9.20			
b)	Shock	9.15			
c)	Vibration	9.16			
d)	Change of temperature	9.24			
e)	Thermal shock (units with glass holder only)	9.19			
f)	Salt mist	9.22			
g)	Composite temperature humidity cycle (moisture resistance)	9.21			
h)	Robustness of terminations	9.17			
j)	General examination (internal)	9.3.2			
	i) Resonator	9.3.2.1			
	ii) Holder cover	9.3.2.2			
	iii) Bond strength	9.3.2.3			
k)	Low temperature storage	9.7			
m)	Accelerated ageing	9.25			

Note — Samples which have been subjected to destructive tests shall not be returned to the lot.

*Sampling plans and procedures for inspection by attributes for electronic items.

†*D* for destructive and *N* for non-destructive.

made with the crystal unit in thermal equilibrium at the same temperature ± deg C, and the drive level set at the same practical minimum. Measured changes in frequency and resonance resistance during the test shall not exceed the respective maximum changes specified for the particular test in question.

However at minimum drive level, it is not necessary that the unit operate within the overall tolerances for frequency and resonance resistance since a change in the drive level does affect the operating characteristics of the crystal, especially its frequency. All crystal units (including those designed for operation at anti-resonance) shall be measured at series resonance.

9.2.2.4 *Measurements after tests* — When resonance frequency or resonance resistance, or both are to be measured after a test to determine compliance with specified tolerances, the measurements shall be made at the specified drive level. For crystal units designed for operation under non-controlled temperature conditions, measurements shall be made with the crystal units in thermal equilibrium at room temperature. For crystal units designed for operation under controlled temperature conditions, measurements shall be made with the units in thermal equilibrium at the reference temperature.

9.2.2.5 *Frequency and resonance resistance measurements* — Unless otherwise specified, for crystal units in metal holders, measurements of frequency or resonance resistance, or both, shall be with the holder grounded; for units with long wire lead terminals, the test point shall be 6·0 ± 1·5 mm from the holder base.

9.2.2.6 *Drive level adjustment* — Where rated drive level is specified for a test, it shall be adjusted immediately before each test. No further adjustment shall be made between measurements during a temperature run test (except in case of line voltage fluctuation or a test lasting longer than hour).

9.2.2.7 *Crystal impedance meter* — The typical test set in a crystal impedance meter whose broad schematic diagram is as shown in Fig. 1.

a) This circuit is a modified colpitts oscillator in which the tank inductor has been effectively divided into two sections L_1 and L_2 between which a resistor $R_0 = R_A$, the effective resistance of a crystal unit may be introduced (which is done by the switch S_1). R_0 may be a variable calibrating resistor or a decade resistor is the set itself. The crystal unit is in series with a calibrated capacitor which may be connected whenever necessary by switch S_2. The gauged tuning capacitors C_1 and C_2 are at all times equal, and both are variable to adjust the natural frequency of the oscillator near the nominal frequency of the crystal. C_B is simply a blocking capacitor to isolate the plate voltage from the crystal terminals and adds only a negligible reactance to the tuned circuit. The potentiometer P is used to control the screen grid voltage and hence the radio frequency output of the tube as well as the drive level of the crystal.

NOTE — In case of crystal impedance meter for high frequencies, L_1 and L_2 are varied instead C_1 and C_2.

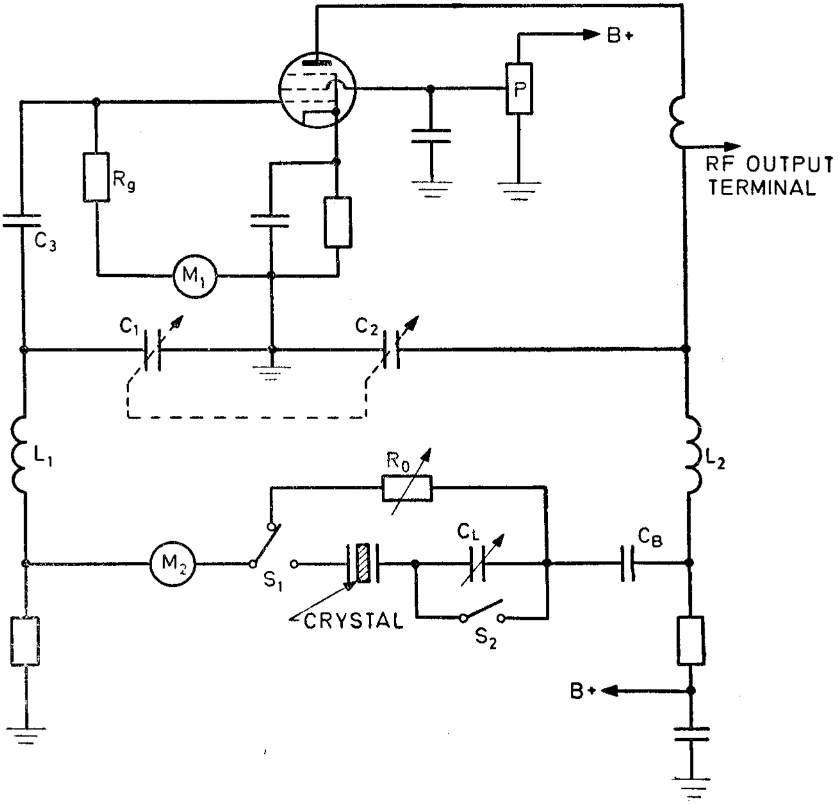


FIG. 1 SIMPLIFIED SCHEMATIC DIAGRAM OF CRYSTAL IMPEDANCE METER

b) The grid current meter is a very sensitive indicator of slight changes in the radio frequency voltage across C_1 and hence of any change in the tank circuit. The crystal current meter M_2 is to indicate the possibility of overloading the crystal and provide a ready means of the exact drive level of the crystal unit tested. By measuring the radio frequency voltage across the crystal (with load capacitor wherever necessary), with the help of terminals to be provided, using an electronic voltmeter and knowing the effective resistance, exact drive level can be calculated.

c) *Measurement of Resonance Resistance R_r and Resonance Frequency f_r*

1) The connections are made with appropriate test set, frequency indicator, standard frequency source and switch S_2 is closed.

2) The crystal unit is inserted in the test set and switch S_1 is put in the crystal position. A small amount of screen voltage (to avoid over-driving the crystals) is given by the potentiometer P, such that, while C_1 and C_2 are varied a peak in the grid current reading is obtained (this in turn means the effective resistance of the crystal unit has reached the minimum value equal to the series arm R). The grid current control is adjusted to give a suitable reading of the meter. The frequency (approximately the resonant frequency of the crystal unit) is measured.

3) Now the position of the switch S_1 is changed to calibrate position, where R_0 is introduced instead of the crystal. R_0 is adjusted to give the same grid current meter readings, at the same frequency as in 2). This R_0 is measured by a bridge, if necessary. This value gives the resonance resistance R_r.

4) With the resonance resistance, the corresponding voltage is calculated by using the formula $E = /PR_r$ (where P is the specified drive level).

5) With switch S_1 changed to crystal position, the correct frequency F_r of the crystal is measured. This is the frequency at series resonance f_r.

d) *Measurement of Anti-Resonance Frequency f_a*

1) The set up is the same as above, with switch S_2 opened and load capacitance C_L adjusted to specified value .

2) The resonance frequency and resonance resistance are measured as specified in c).

3) The frequency measured in anti-resonance frequency f_a.

9.3 General Examination

9.3.1 *General Examination (External)* — The crystal units shall be examined to verify that the external design, construction, physical dimensions, marking and workmanship are in accordance with the applicable requirements.

The design, construction, physical dimensions and workmanship shall be satisfactory. Marking shall be legible and indelible.

9.3.1.1 *Glass parts* — A strong light and a 10 power magnification shall be used to examine the glass parts.

Glass seals in the base of crystal units with metal holders shall be free of cracks. Crystal units with glass holders shall contain no cracks in the glass structure.

NOTE — Minute cracking and flaking around the feather edge of a meniscus which is generally inevitable shall not be considered a crack within the meaning of the specification.

9.3.1.2 *Loose particles* — The crystal units shall be checked by shaking to determine the presence of loose particles.

There shall be no loose particles.

9.3.1.3 *Pin alignment* — For metal holders test gauge or shadow graph as given in Fig. 2 shall be used to determine pin alignment. In the case of glass holders appropriate test gauge shall be used. When bosses appear on the crystal units the gauge must be relieved to admit them.

The pins in the base of the crystal units shall freely and completely enter the pin alignment gauge or if a physical gauge is not used, the dimensions and spacing of the pins shall conform to the limiting test gauge as viewed on the shadow graph.

9.3.2 *General Examination (Internal)* — The crystal units shall be disassembled and the interior shall be examined to verify that the design, construction and workmanship are in accordance with the applicable requirements. For glass-enclosed crystal units, internal examination may be performed visually without disassembly.

The design, construction and workmanship shall be satisfactory.

9.3.2.1 *Resonator* — The crystal resonator shall be inspected with a 10 power magnification under appropriate light conditions.

There shall be no evidence of fractures on resonator and no evidence of loose particles or foreign material on either side of the resonator.

9.3.2.2 *Holder cover (not applicable to glass holders)* — The thickness of the walls of holder cover shall be measured on long sides, above the soldered area and away from the area affected by stamping or engraving.

The thickness shall be as specified in the relevant specification.

9.3.2.3 *Bond strength (applicable to low frequency crystal units below 700 kHz)* — A force, perpendicular to the surface of attachment, shall be gradually applied to each wire or other supporting structures until the specified bond strength value is reached.

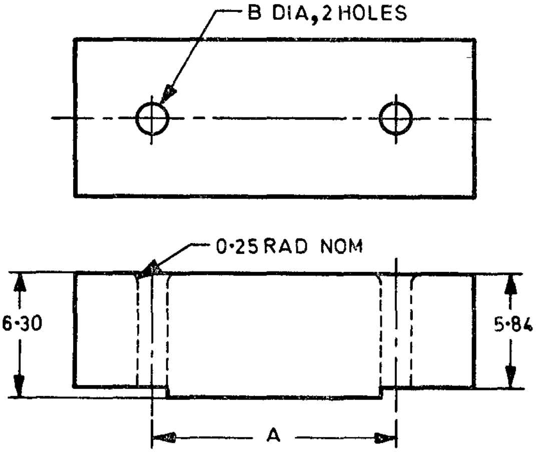
The junction between each supporting wire and the quartz resonator shall have a minimum bond strength as specified in the relevant specification.

The full force shall be applied for not more than one minute. Breakage of the quartz resonator, during this test, shall not be construed as a bond strength failure.

The junction between each supporting wire and the quartz resonator shall have a minimum bond strength as specified.

9.4 Reduced Drive Level (Applicable to Overtone Units and When Specified, Fundamental Units) 1st Method Using CRO

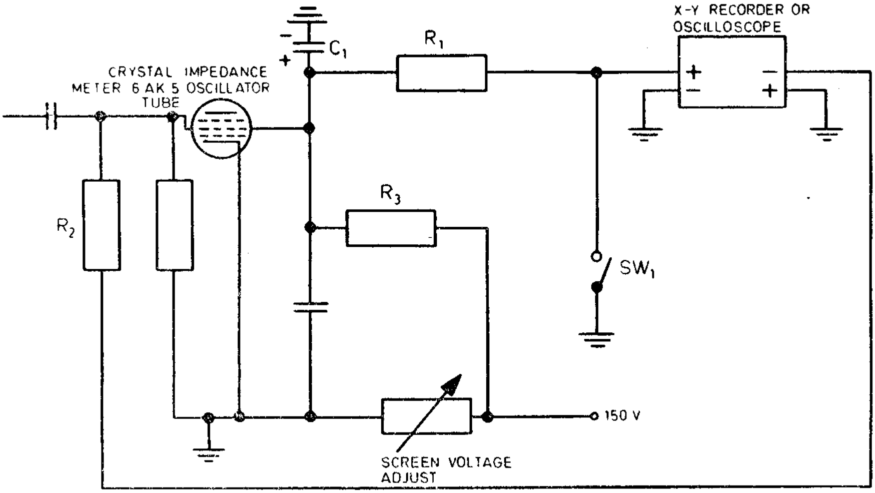
9.4.1 The crystal units shall be tested using the required crystal impedance meter modified as in Fig. 3. The crystal impedance meter is



Nominal Pin Diameter	*A*	*B*
1·02	4·877	1·270
1·27	12·344	1·524

Note — Unless otherwise specified, tolerances are ·*xx* ± 0·08 and ·*xxx* ± 0·013.

Fig. 2 Pin Gauges


X-Y RECORDER OR OSCILLOSCOPE
+
−
−
+
C₁
−
+
R₁
CRYSTAL IMPEDANCE METER 6 AK 5 OSCILLATOR TUBE
R₂
R₃
SW₁
150 V
SCREEN VOLTAGE ADJUST

COMPONENTS ADDED TO APPLICABLE CI METER

C_1 000 μF / 35V
R_1 1 K $\frac{1}{4}$ W
R_2 & R_3 15 K, $\frac{1}{4}$ W
SW_1 NORMALLY OPEN

FIG. 3 MODIFICATION OF CRYSTAL TEST SET (FOR REDUCED DRIVE LEVEL TEST)

adjusted to the nominal frequency. The screen voltage control is adjusted to provide a resonable drive level, not exceeding the specified limit, when a resistor of the maximum,equivalent resistance of the crystal type under test is inserted into the crystal socket. The screen voltage output terminals (VG2) on the crystal impedance meter are connected to ' Horizontal Input ' of the oscilloscope and the horizontal input selector is switched to ' EXT × 10 ' position. The ' Adj. variable 10-1 ' control is set to the desired speed and limit. The applicable VG1 output terminals are then connected to ' Plug-in-Unit ' of the scope with the sensitivity at ' 0·05 V/cm ' and input selector-switch at ' DC '.

9.4.2 SW_1 is then closed and the scope is adjusted such that ' DOT ' on the scope is in the lower left hand side corner (preferably at the left hand side of the centre line of the Graticule) SW_1 is opened. The screen voltage will now increase and move the ' DOT ' along the centre line as the 1 000 μF capacitor charges via R_3 (15 000Ω) and the ' DOT ' moves diagonally when the screen voltage is such that oscillation starts. The point at which the oscillation starts or diagonal movement starts is noted.

9.4.3 The resistor is removed, SW_1 is now closed while the crystal is inserted into the socket. The ' DOT ' is properly set again as **9.4.2.** SW_1 is opened. The 'DOT ' will again move along the centre line until a point is reached at which oscillation starts, at which time ' DOT' moves diagonally. This point of oscillation is noted down. SW_1 is closed and the crystal unit is removed from the test socket of the C_1 meter.

9.4.4 The point of oscillation for the crystal should be lower than that of the point of oscillation for a maximum specified resistance of the crystal units.

Note — In place of oscilloscope, an *X-Y* recorder could be used if available.

9.5 Capacitance Shunt

9.5.1 The capacitance of the specimen shall be measured between the two terminations with crystal holder ungrounded, at or referred to an ambient temperature of 25°C with a capacitance bridge or other suitable method, at a frequency which is lower than the fundamental frequency of the unit, and at which the unit shows no oscillation response. Suitable measuring technique shall be used to minimise errors due to the connection between the measuring apparatus and the specimen. The ac voltage actually impressed across the specimen shall be as low as practicable. The accuracy of measurement shall be ± 0·5 percent + 0·2 pF.

9.5.2 The capacitance shunt shall be as specified in the relevant specification.

9.6 Resonance Frequency and Resonance Resistance

9.6.1 The resonance frequency and resonance resistance of the crystal unit shall be measured at the specified drive level with the crystal unit operating in the applicable test set (specified in detail specification) and in thermal equilibrium at the following temperatures:

a) *Non-controlled temperature unit* — Under atmospheric conditions for testing at 25 ± 2°C, and

b) *Controlled temperature unit* — At the reference temperature and if specified under atmospheric conditions for testing.

9.6.2 The resonance frequency and resonance resistance of the crystal unit shall be within the limits specified in the relevant specification.

9.7 Low Temperature Storage

9.7.1 The crystal units shall be subjected to the lowest temperature of the operating temperature severity for two hours. The resonance frequency and resonance resistance shall be measured at this temperature.

9.7.2 The resonance frequency and resonance resistance shall be as specified.

9.8 Temperature Run

9.8.1 *Operating Temperature and Frequency Stability (Controlled Styles)* — The crystal units shall not be disassembled and indirect means shall be used for determining the temperature of the resonator. Measurements of resonance frequency and resonance resistance of the crystal unit designed for operation under controlled temperature conditions, shall be performed at specified resonance and rated drive level by either of the following methods:

> *Method A — Continuous* — Measurements shall be taken continuously over the operating temperature range. The rate of temperature change shall not exceed 2 deg C per minute.
>
> *Method B — Incremental* — Measurements shall be taken over the operating temperature range at intervals not greater than 2·5 deg C. These measurements include the two extremes as well as the reference temperature, assuring that the resonator has reached thermal equilibrium before each measurement is made.

The resonance frequency of crystal unit shall not deviate from the measured frequency at the reference temperature by more than the value specified and shall also be within the specified frequency tolerance limits.

9.8.2 *Operating Temperature Range (Non-controlled Styles)* — The crystal unit shall not be disassembled, and indirect means shall be used for determining the temperature of the resonator. Measurements of resonance frequency and equivalent resonance resistance of the crystal unit designed for operation under non-controlled temperature conditions, shall be performed at specified resonance and rated drive levels as follows:

The temperature of the crystal unit shall be varied so as to traverse the entire operating range from low temperature to high temperature. For the operating temperature range of — 55 to + 105°C, the temperature range shall be traversed in 8 ± 1 minutes unless otherwise specified. For other operating temperature ranges, the time shall be proportional. Measurement of frequency and equivalent resistance shall be recorded continuously or at intervals of not over 3°C to ascertain that tolerances are not exceeded at any instant. The temperature measurements shall be accurate to within ± 1°C for minimum and maximum operating temperature limits. The end point frequencies shall be within ± 5 percent of the specified overall frequency tolerance when compared to the equilibrium frequency at these end point temperatures.

For example, if the specified frequency tolerance is ± 0·005 percent (over all 100 ppm) then the end point tolerance is 5 ppm. The temperature run shall be performed automatically from the low temperature to the high temperature using a suitable temperature coefficient analyser. No manual adjustments shall be made to the test set up once the temperature run has begun.

9.8.3 *Operable Temperature Range* (*Controlled Styles*) — The crystal units designed for operation under controlled temperature conditions shall be subjected to a temperature run over the operable temperature range. The rate of change of temperature shall not exceed 2·5 deg C per second. The unit shall be monitored for continuous oscillation, but for the purpose of this test, measurements of frequency and equivalent resistance are not required unless otherwise specified.

The crystal unit shall oscillate continuously.

9.9 Unwanted Response

9.9.1 *Method I* (*Fundamental Units*) — The test for unwanted modes shall be performed at room temperature on crystal units designed for operation under non-controlled temperature conditions. For controlled temperature units, the test shall be performed with the crystal unit in thermal equilibrium at the reference temperatures:

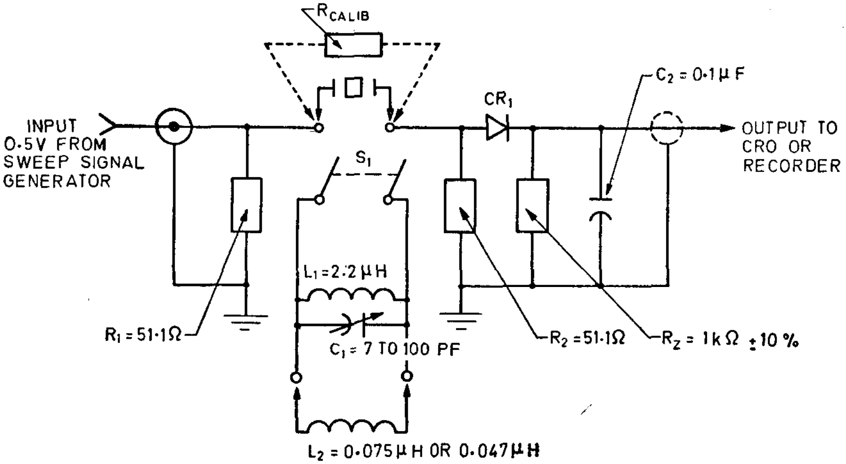
a) The test shall be performed at rated drive level;

b) Determine the value of maximum equivalent resistance. Insert a fixed resistor equal to this value in the test set. Adjust the output frequency of the test set to a frequency 20 percent lower than the specified frequency, and then to a frequency 20 percent higher than the specified frequency. The adjacent band of the test set, or another test set shall be used when necessary;

c) Record the dial settings of the tuning control on the test set obtained in (b);

d) Replace the fixed resistor with the crystal unit. The test set should beat the plus 20 percent frequency setting before inserting the crystal unit; and

e) Slowly vary the tuning control between the dial setting recorded in (c), begining with the setting 20 percent higher than the specified frequency, while monitoring the output signal.



NOTE 1 — R_1 and R_2 are metal film resistors with tolerances of ±1 percent.

NOTE 2 — R_{calib} has been shown by dotted lines since it indicates that the crystal unit can be replaced by suitable resistor to determine the level of unwanted response.

FIG. 4 CIRCUIT DIAGRAM FOR THE MEASUREMENT OF UNWANTED RESPONSE

Unless otherwise specified, there shall be no unwanted modes of oscillation resonant frequencies other than the desired operating frequency. In addition, there shall be no abrupt frequency shifts and no intermittent oscillations (some crystals units may not start oscillating immediately at the plus 20 percent setting, or may cease oscillating during detuning, without resumption of oscillation on further detuning. These conditions are permitted).

9.9.2 *Method II (Applicable to Overtone Units and, when Specified, to Fundamental Units)* — Crystal units shall be tested using the test circuit as shown in Fig. 4. The test shall be performed at room temperature for all crystal units. A frequency range of approximately 200 kHz above and 200 kHz below the specified frequency shall be swept by the signal generator. S_1 shall be set in the open position for crystal units with operating frequencies below 12 MHz. For crystal units with operating frequencies above 12 MHz, S_1 shall be set in the closed position, the proper inductance value for L_2 shall be used, and C_1 shall be adjusted to parallel resonate the static capacitance (C_0) as evidenced by an indication of zero or minimum amplitude on the oscilloscope or recorder. The output oscilloscope or recorder shall be observed for unwanted modes.

All unwanted modes shall have a resistance that exceeds 2 times the main mode resistance but is not less than the specified main mode resistance values.

However for filter crystal the detail specification should specify the sweep frequency range and the permissible suppression level.

9.10 Motional Capacitance — In accordance with IS : 7962-1975*.

9.11 Motional Inductance — In accordance with IS : 7962-1975*.

9.12 Insulation Resistance — The insulation resistance shall be measured with a direct voltage of 100 ± 15 V and for 1 minute ± 5 seconds or less if stable readings are obtained between:

a) terminations, and

b) the terminations connected together and metal parts of the case if any.

The insulation resistance shall not be less than 500 M ohms unless otherwise specified.

NOTE — Voltages other than the above may be used provided that correlation can be established.

9.13 Crystal Q Values

9.13.1 The crystal Q values (if specified) shall be greater than the minimum values specified. Crystal Q values can be determined by the expression:

$$Q = \frac{1}{4\pi \Delta f (C_0 + C_L) R}$$

where

Δf is $(F_a - F_r)$ expressed in hertz, where F_a is the anti-resonant frequency with a load capacitance of $(C_0 + C_L)$ pF;

F_r is the frequency of resonance as measured by the methods specified in **9.6**;

$(C_0 + C_L)$ is the total load capacitance;

C_0 is the parallel capacitance measured as specified in **9.5**;

C_L is an external capacitance in series with the crystal unit used to measure anti-resonant frequency F_a; and

R is the resonance resistance of the crystal units.

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*Methods of measurement for piezoelectric vibrators operating over the frequency range up to 30 MHz.

9.14 Bump

9.14.1 The crystal units shall be subjected to the bump test in accordance with Section 2 of IS : 9000 (Part VII)-1979*.

9.14.2 The crystal units shall then be visually examined. There shall be no visible damage.

9.14.3 The resonance frequency and resonance resistance shall then be measured. The change of resonance frequency and resonance resistance compared with the values obtained from the measurements made prior to the conditioning shall not exceed the specified limits.

9.14.4 If this test is included in the relevant specification, the following shall be specified:

a) The degree of severity of the test, and
b) The axes along which the force shall be applied.

9.15 Shock

9.15.1 The crystal units shall be subjected to the shock test in accordance with Section 1 of IS : 9000 (Part VII)-1970† for half sine pulse with peak acceleration of 1 000 m/s^2 and 6 ms duration. The specimens shall be mounted using a method which rigidly supports the body of the crystal unit and assures that the crystal holder is experiencing the specified shock level.

9.15.2 *Initial Measurements* — The following measurements shall be made prior to the commencement of the test.

a) Resonance frequency, and
b) Resonance resistance.

9.15.3 *Final Measurements* — On completion, the following measurements shall be made.

a) Visual examination — There shall be no mechanical damage.
b) Resonance frequency — The change from the value recorded earlier at **9.15.2** shall not exceed that specified, and
c) Resonance resistance — The change from the value recorded earlier at **9.15.2** shall not exceed that specified.

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*Basic environmental testing procedures for electronic and electrical items: Part VII Impact test, Section 2 Bump.

†Basic environmental testing procedures for electronic and electrical items: Part VII Impact test, Section 1 Shock.

9.16 Vibration

9.16.1 The crystal units shall be subjected to the vibration test in accordance with **7.6** of IS : 589-1961* with the following severities A & B as specified.

Severity Reference	*Frequency in Hz*	*Amplitude Displacement/Peak Velocity*	*Total Duration, h*
A	10 to 55	0·75 mm	2
B	10 to 500	0·75 mm or 100 m/s^2 whichever is less	3

9.16.2 The specimen shall be rigidly mounted on the horizontal platform of the vibration machine in such a manner that the applied vibration shall be as follows:

a) One-third of the units (to the nearest integral number) shall have the direction of vibration parallel to the pin length,

b) The same number of units shall have the direction of vibration perpendicular to the largest surface, and

c) The remainder of the units shall have the direction of vibration perpendicular to the pin length and parallel to the largest surface.

9.16.3 *Initial Measurements* — The following measurements shall be made prior to the commencement of the test.

a) Resonance frequency, and

b) Resonance resistance.

9.16.4 *Final Measurements* — On completion, the following measurement shall be made.

a) Visual examination — There shall be no mechanical damage,

b) Resonance frequency — The change from the value recorded earlier at **9.16.3** shall not exceed that specified, and

c) Resonance frequency — The change from the value recorded earlier at **9.16.3** shall not exceed that specified.

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*Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

9.17 Robustness of Terminations

9.17.1 The crystal units shall be subjected to the robustness of terminations test in accordance with IS : 9000 (Part XIX/Sec 1 to 5)-1978*. The following procedures will be adopted.

9.17.2 *Tensile Test (All Terminations)* —Procedure 1. Pin termination 20 N load, wire load terminations — 10 N load.

There shall be no evidence of damage to the terminal glass seal or movement of the terminal relative to the glass at the point of seal.

9.17.3 *Bending Test (Undercut Pin Terminations)* — Each termination shall be subjected to the severity chosen from the severities given at **18**(c) of IS: 9000 (Part I)-1977†. The following details and exceptions shall apply.

a) Applicable bending tool to be in accordance with the Fig. 5 (Any convenient means may be used for holding the body or base of the crystal unit). The tool shall engage that segment of the pin terminals beyond the undercut portion. To ensure that bending will occur primarily at the undercut portion, a plate with the clearance holes for the pins may be placed over the pins. This plate may be of such thickness as to include a portion of the undercut section of the pins,

b) Number of bending cycles — Two, and

c) The bending cycle shall start with a 15 ± 2° bend in one direction followed by a bend of 30° ± 2° in the opposite direction and completed by a bend 15° ± 2° back to the starting position.

There shall be no breakage of terminal and cracking or chipping of glass seals.

9.17.4 *Bending Test (Wire Lead Terminations)* — Procedure (*see* **9.17.3**) 5 N load.

There shall be no severing of the terminal or cracking or chipping of the glass.

9.18 Sealing — The crystal units shall be tested as follows.

9.18.1 *Liquid Immersion Method (Gross Leak Test) (Crystal Units in Metal Holders)* — The method of test shall be carried out as stated below:

a) *Initial measurements* — The resonance frequency shall be measured as per **9.6.1**. The specimen shall be tested for gross leaks by immersion in distilled water, with a pressure applied of 550 kPa for a period of 5 minutes. The distilled water shall be freely applied for each sample group tested, and

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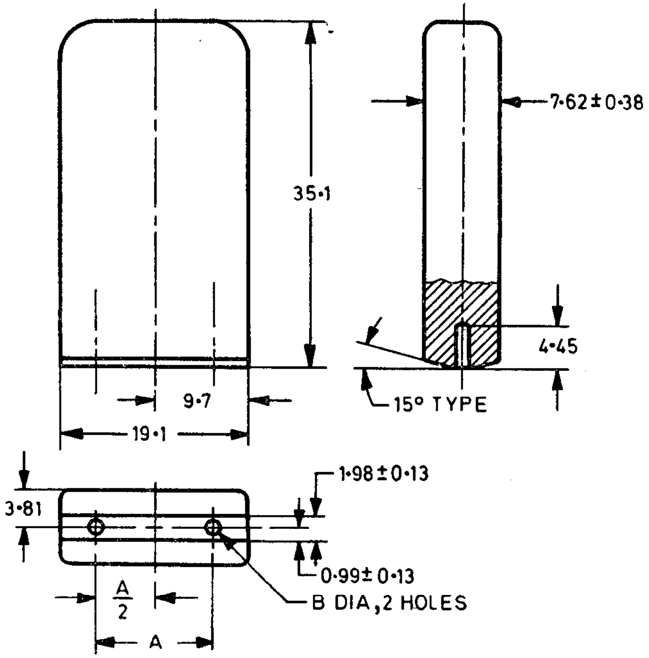
*Basic environmental testing procedures for electronic and electrical items: Part XIX Test robustness of terminations and integral mounting devices.

†Basic environmental testing procedures for electronic and electrical items: Part I General.

b) *Final measurements* — The resonance frequency shall be measured according to **9.6.1**. The change in frequency from the value recorded shall not exceed 0·0005 percent unless otherwise specified. Insulation resistance shall also be measured according to **9.12**.



NOMINAL PIN DIAMETER	*A*	*B*
1·02	4·877	1·321
1·27	12·344	1·000

NOTE — Unless otherwise specified, tolerances are ·x ± 0·5, ·× × ± 0·08 and ·×x × ± 0·013.

FIG. 5 TOOL FOR TERMINAL BEND TEST

9.18.2 *Tesla Coil Method* (*Crystal Units in Glass Holders*) — Crystal units in glass holders shall be subjected to three heat cycles, each cycle consisting of the following three steps:

a) Increase temperature to 100°C ± 5 deg C at a rate not faster than 2 deg C per minute, and

b) Hold temperature at 100°C ± 5 deg C for 30 minutes.

c) Cool to room temperature at a rate not faster than 2 deg C per minute. Store for a minimum period of 24 hours. After this storage period in a dark room with the crystal unit resting on a dark nonmetallic surface bring an energised Tesla coil into proximity with the end of crystal unit opposite the terminals. The Tesla coil intensity shall be adjusted for a discharge of 3·2 to 4·8 mm from the metal probe tip to a ground metal object. The maximum exposure time shall be one second.

(CAUTION : The Tesla coil power may be turned off when not in use; however, no further spark intensity adjustment shall be made.)

The Tesla coil probe should not be brought in to direct contact with the crystal bulb or terminations.

When the Tesla coil probe is brought to within 12·7 mm of the unit, a characteristic blue glow shall be seen. Failure of the blue glow to appear is an indication of an unsatisfactory seal. In no case should a visible spark be seen between the Tesla coil and the crystal unit.

9.19 Thermal Shock (Applicable to Crystal Units with Glass Holders)

9.19.1 The crystal unit shall be tested in accordance with **7.14.2** of IS : 589-1961* using the water-bath method specified in **7.14.2.3**(a) of IS : 589-1961*. The crystal units shall be immersed in boiling water for 15 ± 1 seconds and immediately thereafter be immersed in water for 5 ± 1 seconds. The volume of water shall be large enough so that its temperature will not be appreciably affected when the specimens are introduced.

9.19.2 There shall be no evidence of cracking, chipping, or breaking in any part of the crystal unit.

9.20 Soldering (for Crystal Units with Termination Intended for Soldering Only)

9.20.1 The crystal units with termination intended for soldering only shall be subjected to solder bath test in accordance with **7.18.2** of IS : 589-1961* at 230 ± 10°C.

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*Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

9.20.2 The unit shall be visually examined. There shall be no visible damage.

9.21 Composite Temperature/Humidity Cyclic (Moisture Resistance)

9.21.1 The crystal units shall be subjected to the test in accordance with IS : 9000 (Part VI)-1978* using the severity 10 cycles.

9.21.2 *Initial Measurements* — The following measurements shall be made prior to the commencement of the test:

a) Resonance frequency,
b) Resonance resistance, and
c) Insulation resistance.

9.21.3 *Final Measurement* — On completion, the following measurements shall be made:

a) Visual examination — There shall be no mechanical damage,
b) Resonance frequency — The change from the value recorded earlier at **9.21.2** shall not exceed that specified,
c) Resonance resistance — The change from the value recorded earlier at **9.21.2** shall not exceed that specified, and
d) Insulation resistance — There shall be no change from the value recorded earlier.

9.22 Salt Mist

9.22.1 This test shall be carried out in accordance with **7.10** of IS : 589-1961† with the following severities:

Salt solution : 5 percent,
Duration : 48 hours, and
Temperature : 35 ± 2°C.

9.22.2 The following measurement shall be made allowing recovering after cleaning:

a) Visual examination,
b) Resonance frequency, and
c) Resonance resistance.

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*Basic environmental testing procedures for electronic and electrical items: Part VI Composite temperature/humidity cyclic test.

†Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

9.22.3 There shall be no evidence of excessive corrosion. Corrosion shall be considered excessive that causes impairement of electrical or mechanical performance of the unit.

9.23 Ageing

9.23.1 When a test at elevated temperature is specified, the crystal unit shall be placed in a chamber conforming to **7.2.1** of IS : 589-1961*.

9.23.2 The crystal units shall be subjected to the ageing temperature for a continuous period of 30 days as given below:

	Ageing temperature
a) Non-controlled crystal units with upper operating temperature > 85°C	85 ± 2°C
b) Non-controlled crystal units with upper operating temperature < 85°C	At highest temperature of the operating temperature ±2°C
c) Controlled crystal units	Reference temperature ±2°C

9.23.3 As soon as the crystal unit has reached thermal stability at the test temperature; the resonance frequency and resonance resistance shall be measured and recorded.

9.23.4 At the measurement intervals, once in 3 days, during the period called for in **9.23.2** and at the end of that period, the resonance frequency and resonance resistance shall be measured.

The difference between the initial ageing measurement temperature and subsequent measurement temperature shall not exceed 0·5°C.

9.23.5 The difference between the highest and the lowest frequencies measured shall not exceed the value specified.

9.24 Change of Temperature

9.24.1 The crystal units shall be subjected to the test in accordance with IS : 9000 (Part XIV)-1978† except for the following:

Step	*Temperature*
1	-65^{+0}_{-5}
2	25^{+10}_{-5}
3	125^{+}_{-0}
4	25^{+10}_{-5}

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*Basic climatic and mechanical durability tests for components for electronic and electrical equipment (*revised*).

†Basic environmental testing procedures for electronic and electrical items: Part XIV Change of temperature.

Unless otherwise specified the specimen shall be mounted by their normal means in such a position with respect to the air stream that there is substantially no destruction to the flow of air across and around the specimen.

9.24.2 *Initial Measurements* — The following measurements shall be made prior to the commencement of the test:

a) Resonance frequency, and

b) Resonance resistance.

9.24.3 *Final Measurements* — On completion, the following measurements shall be made:

a) Visual examination — There shall be no mechanical damage,

b) Resonance frequency — The change from the value recorded earlier at **9.24.2** shall not exceed that specified, and

c) Resonance resistance — The change from the value recorded earlier at **9.24.2** shall not exceed that specified.

9.25 Accelerated Ageing

9.25.1 *Initial Measurements* — The following measurements shall be carried out:

a) Resonance frequency, and

b) Resonance resistance.

9.25.2 The specimens shall then be conditioned in an oven at 105° ± 3°C for 168 hours. The specimen shall then be removed from the oven and allowed to stabilize at the same room ambient temperature (±7°C).

9.25.3 *Final Measurements*—The following measurements shall be carried out:

a) Resonance frequency — The difference between the initial and final frequency shall not exceed 5 ppm or the value as specified, and

b) Resonance resistance — The value shall not exceed the maximum specified in the relevant specification.

APPENDIX A

(*Clause* 6.1)

EXAMPLES OF TOLERANCE QUOTATION

A-1. For a unit with wide operating temperature range (for example − 40 to + 70°C) for uses where a close tolerance on frequency is not required:

Maximum permissible frequency deviation over the operating temperature range with respect to the nominal frequency is $\pm 200 \times 10^{-6}$.

A-2. For a unit with wide operating temperature range and where it is necessary to specify frequency tolerance at a given temperature:

Maximum permissible frequency deviation over the operating temperature range with respect to the nominal frequency is $\pm 50 \times 10^{-6}$, and

The maximum permissible frequency deviation at 20°C with respect to the nominal frequency is $\pm 10 \times 10^{-6}$.

A-3. For a unit to be used under temperature controlled condition (for example, at 75 ± 5°C) it is usual to give following tolerances:

Maximum permissible frequency deviation over the operating temperature range with respect to the nominal frequency is $\pm 20 \times 10^{-6}$, and

The maximum frequency deviation over the operating temperature range with respect to the measured frequency at 75°C is $\pm 5 \times 10^{-6}$,

INDIAN STANDARDS

ON

PIEZOELECTRIC DEVICES FOR FREQUENCY CONTROL AND SELECTION

IS:	
1885 (Part XLIV)-1978	Electrotechnical vocabulary: Part XLIV Piezoelectric devices
2916 (Part II)-1972	Quartz crystal units used in oscillators: Part II Type AA-01
2916 (Part III)-1972	Quartz crystal units used in oscillators: Part III Type AA-02
2916 (Part IV)-1972	Quartz crystal units used in oscillators: Part IV Type AA-03
2916 (Part V)-1972	Quartz crystal units used in oscillators: Part V Type AA-04
2916 (Part VI)-1972	Quartz crystal units used in oscillators: Part VI Type AA-05
2916 (Part VII)-1975	Quartz crystal units used in oscillators: Part VII Type AA-06
2916 (Part VIII)-1976	Quartz crystal units used in oscillators: Part VIII Type AA-07
2916 (Part IX)-1976	Quartz crystal units used in oscillators: Part IX Type AA-08
2916 (Part X)-1977	Quartz crystal units used in oscillators: Part X Type AA-09
4570-1968	Specification for crystal holders
5575 (Part I)-1970	Temperature control devices for quartz crystal units (heating type): Part I General requirements and tests
5575 (Part II)-1978	Temperature control devices for quartz crystal units (heating type): Part II Pin connection and bases
6133 (Part I)-1971	Piezoelectric filters for use in telecommunication and measuring equipment: Part I General requirements for tests
6537-1972	Guide to the use of temperature control devices for crystal units
7410 (Part I)-1974	Guide to the use of the piezoelectric filters: Part I Quartz crystal filters
7410 (Part II)-1975	Guide to the use of the piezoelectric filters: Part II Piezoelectric ceramic filters
7957-1976	Basic method for the measurement of resonance frequency and equipment series resistance of quartz crystal units by zero phase technique in a π-network
7962-1975	Methods of measurement for piezoelectric vibrators operating over the frequency range up to 30 MHz
8011-1976	Methods for the measurement of frequency and equivalent resistance of unwanted resonances of filter crystal units
8271 (Part I)-1981	Specification for quartz crystal units used for frequency control and selection: Part I General requirements and tests
8899-1978	Guide for the use of synthetic quartz crystal
9018-1978	General requirements and tests for quartz crystal oscillators
9709-1980	Synthetic quartz single crystal
9728-1981	Phase offset method for measurement of motional capacitance of quartz crystal units